Possible In-kind Contributions in Accelerator

Warsaw University of Technology

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Kraków, 2014.03.25

Warsaw University of Technology

The largest technical university in Poland

- Education specialties – 30
- Faculties – 20
- Students – nearly 36 000
- Academic staff – 2 500 (500 prof.)
- Total staff – 5 000

WARSAW UNIVERSITY OF TECHNOLOGY

Faculty of Electronics and Information Technology

- The largest department (~ 15%) of WUT
- ~ 3 800 students
- 6 institutes

Institute of Electronic Systems

- ~ 80 staff members
- 5 divisions, here we represent:
  - Electronics Laboratory for High Energy Particles (ELHEP)
  - Microvawe Circuits and Instrumentation Division (MCID)

- Experienced teams in design of electronics systems for high-energy physics applications
  - Eg. analog and digital circuits, microwave electronics, signal integrity, firmware and software simulations and modern measurement methods

„Nuclear” Sciences at WUT

- Electrical Engineering
- High Power and Nuclear Engineering
- Electronics Engineering
- IT and Computer Science
- Material Engineering
- Mechanical Engineering and Machine Constr.
- Physics
- Chemistry

Around 150+ people, 15 groups, plus Ph.D. students

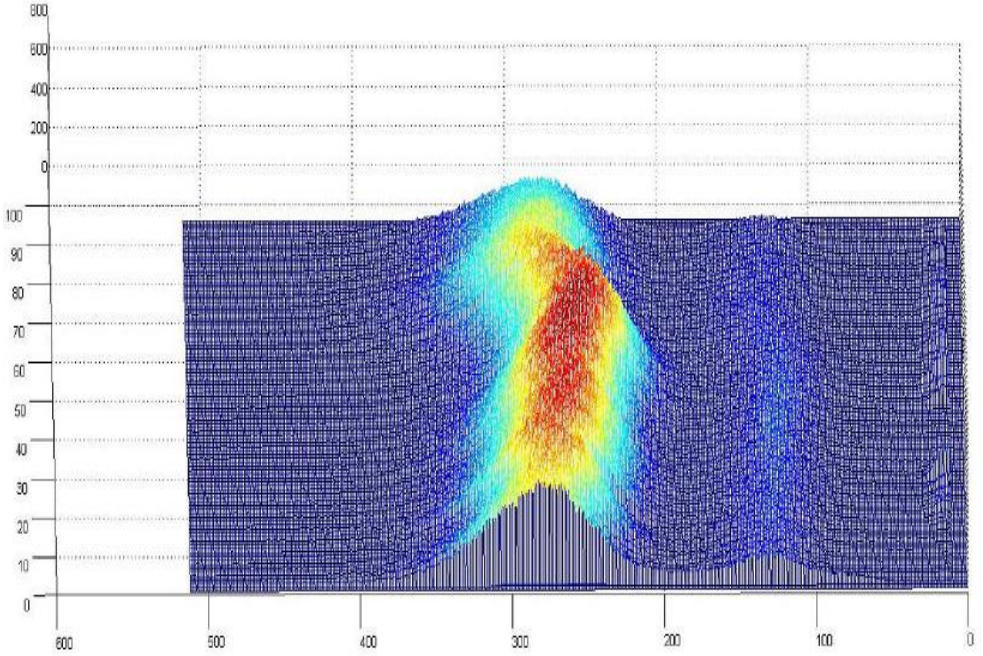
WUT Involvements

- CERN: LHC, CMS, Alice, TOTEM, CERN2GS
- Germany: DESY (FLASH, XFEL), GSI, BESSY, HZDR (ELBE)
- Japan: T2K
- Russia: Dubna JINR
- France: IN2P3, CEA, ITER
- UK: JET
- Italy: INFN
- Spain: Alba
- USA: Fermilab, CEBAF, SLAC
- Chile: ESO, Cherenkov Telescope

Particle Detector Readout Systems

JET X-ray spectrometer

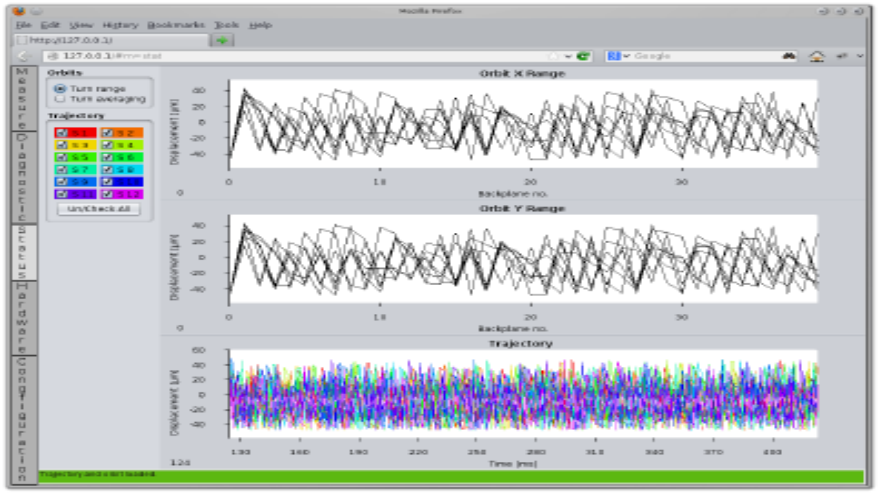
- 512 AFE+ ADC channels, 100MS/s, 10 bit
- Custom processing backplane
- 48 FPGA used
- Embedded x86 CPU
- Dedicated multi-channel HV supply

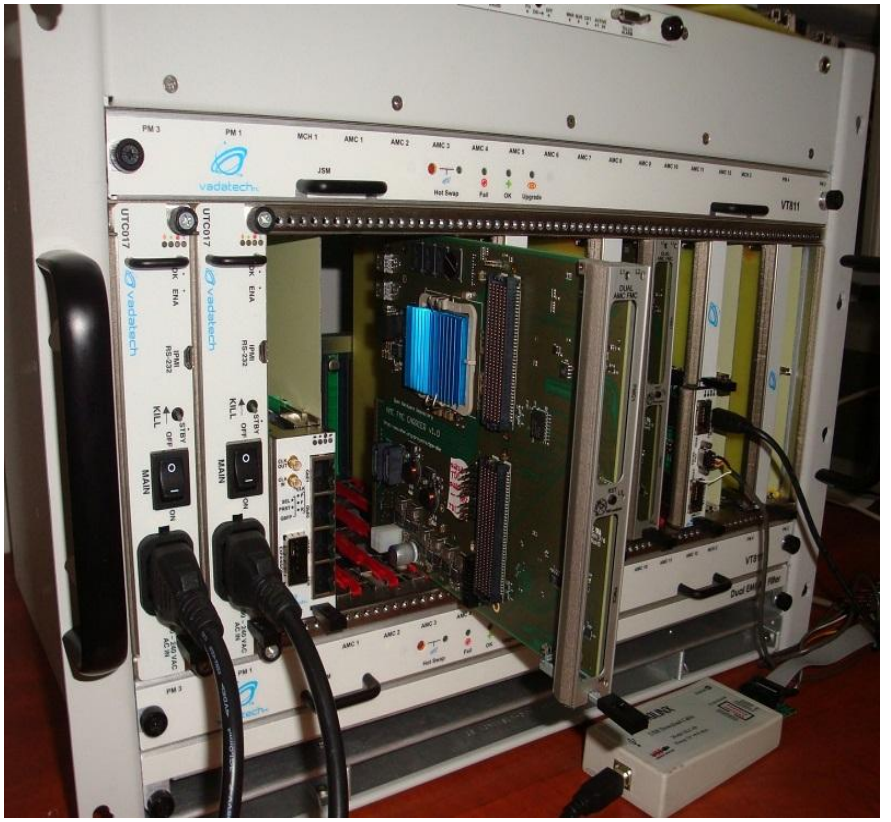


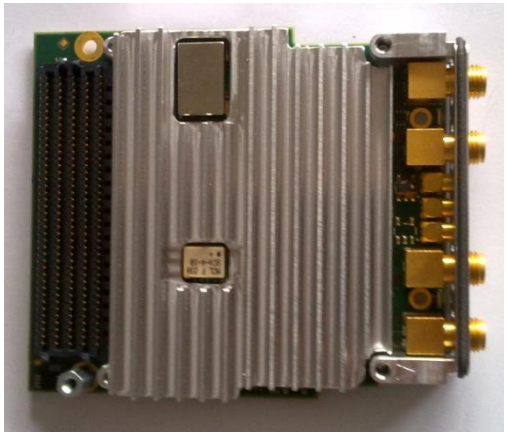
2D map individual histograms for each readout channel for Fe radiation source, HV = 5550 V

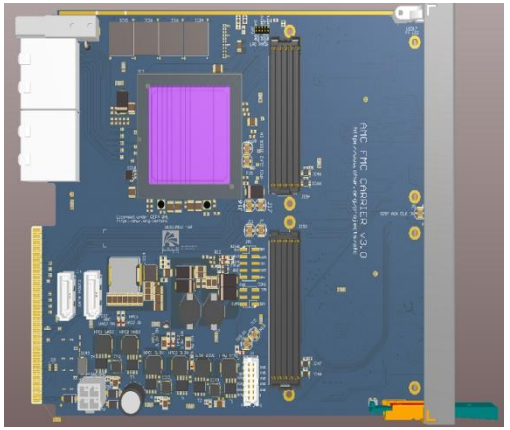
Accelerator Diagnostics

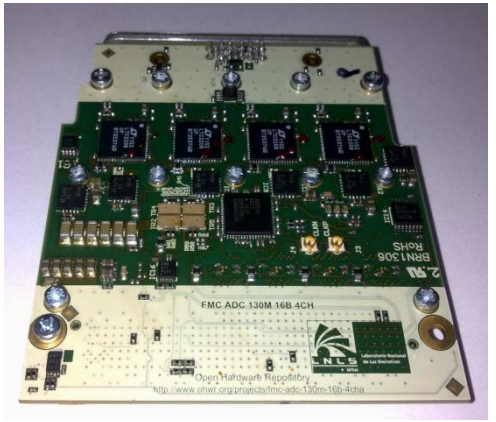
- MTCA.4 based systems
- Trajectory and orbit measurement
- Adaptive PLL algorithm in FPGA
- Custom AMC and FMC ADC
- Sub-ns synchronisation, WR-enabled





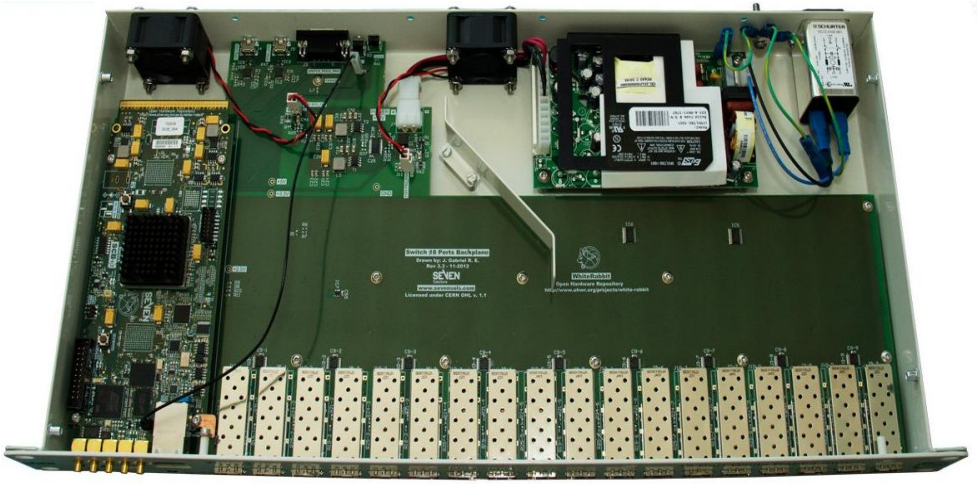


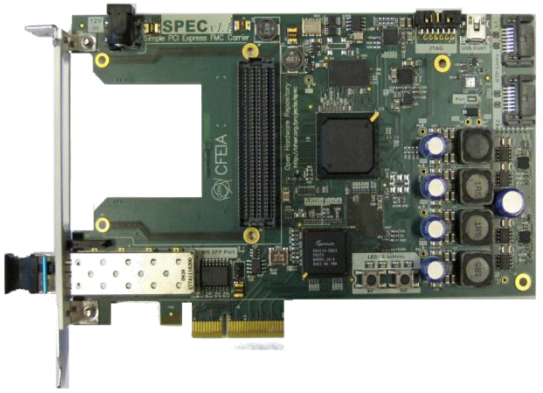




White Rabbit Developments

- Cooperation with CERN
- Sub-ns time synchronization system based on Ethernet
- Deterministic latency
- RF distribution
- Up to 2000 nodes
- Tens of km range
- Fully custom design, 1000Base-X
- Commercially available
- Applications:
  - Accelerator control and timing system (CERN, GSI)
  - Distributed Direct Digital Synthesis (TTC, RF, bunch clock)
  - Distributed oscilloscope
  - Time distribution in Large High Altitude Air Shower Observatory



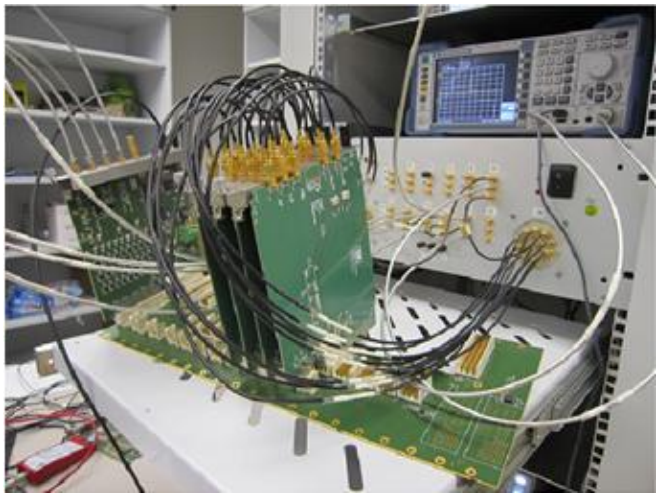


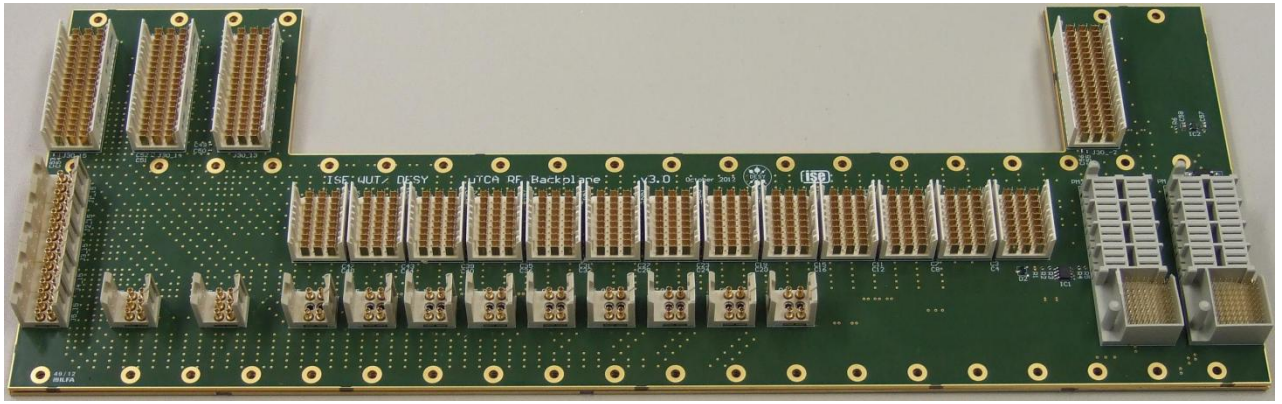
Example Projects for MTCA Based LLRF Control System for XFEL and Other Accelerators

10-channel Downconverter
uRTM form factor
1.3GHz -> 54 MHz
WUT, DESY

2-channel Vector Modulator
uRTM form factor
100 MHz - 6GHz
WUT, TUL

Automated teststand for MTCA components
WUT





RF Backplane for MTCA crates
Simplifies cable management
WUT, DESY

Master Oscillator System for FLASH

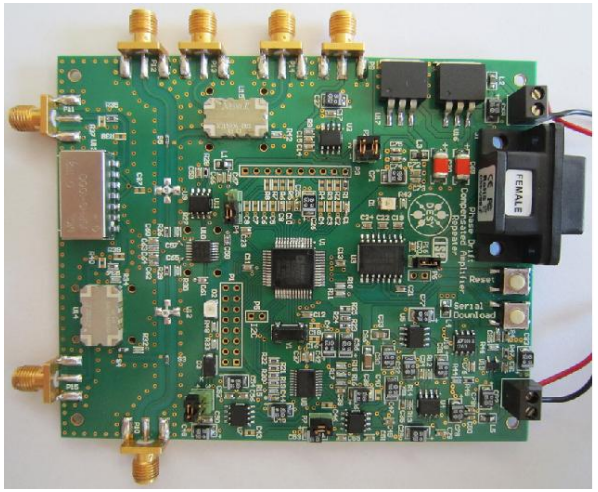
Injector Area

H3 Extension Subdistribution

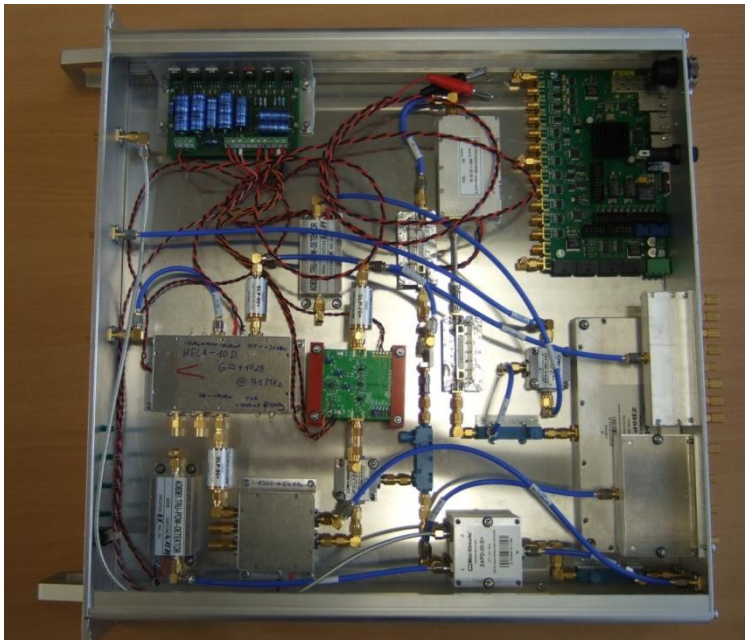
Team work of DESY and MCID engineers. Many subcomponents of the system were developed in Warsaw

Developments for fs Synchronization Systems

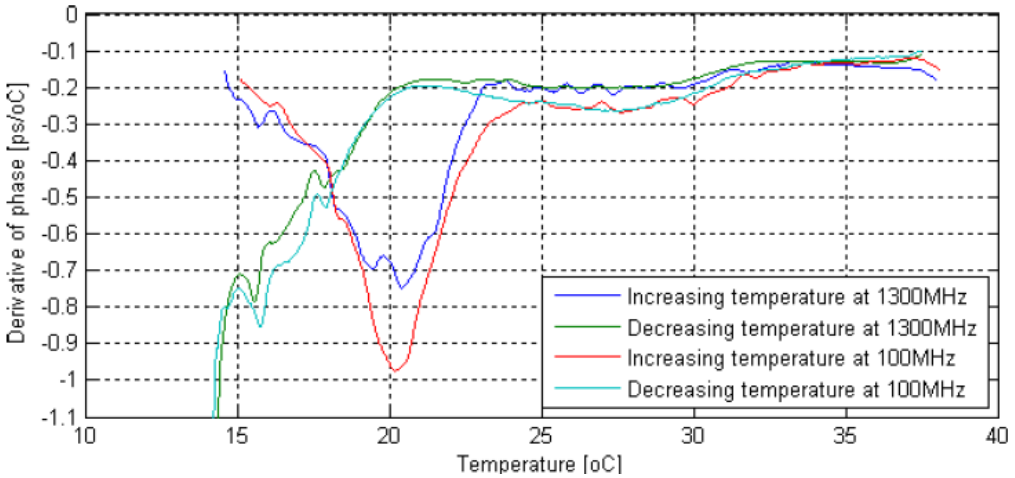
Active compensation of RF amplifier phase drifts



|Ultra stable 1.3 GHz -> 1.354 GHz LO Generator



Automated test stand for cable phase drift measurements



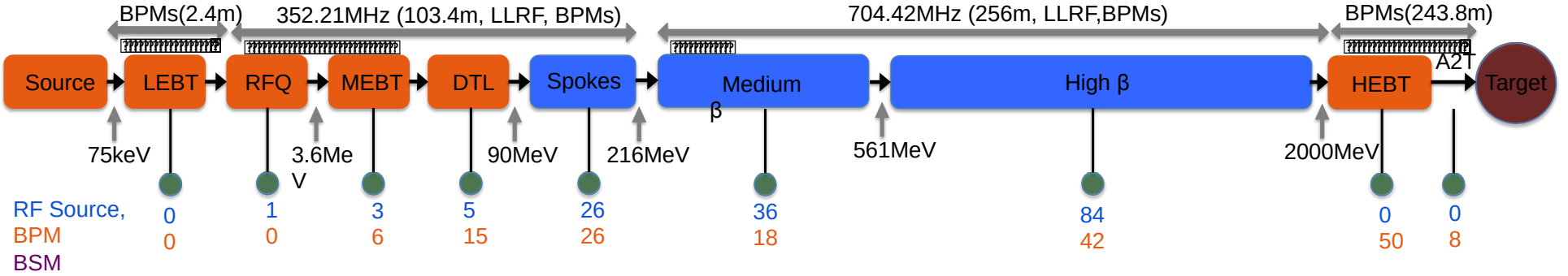
Possible In-Kind Contribution from WUT

WBS: ACCSYS.8.3

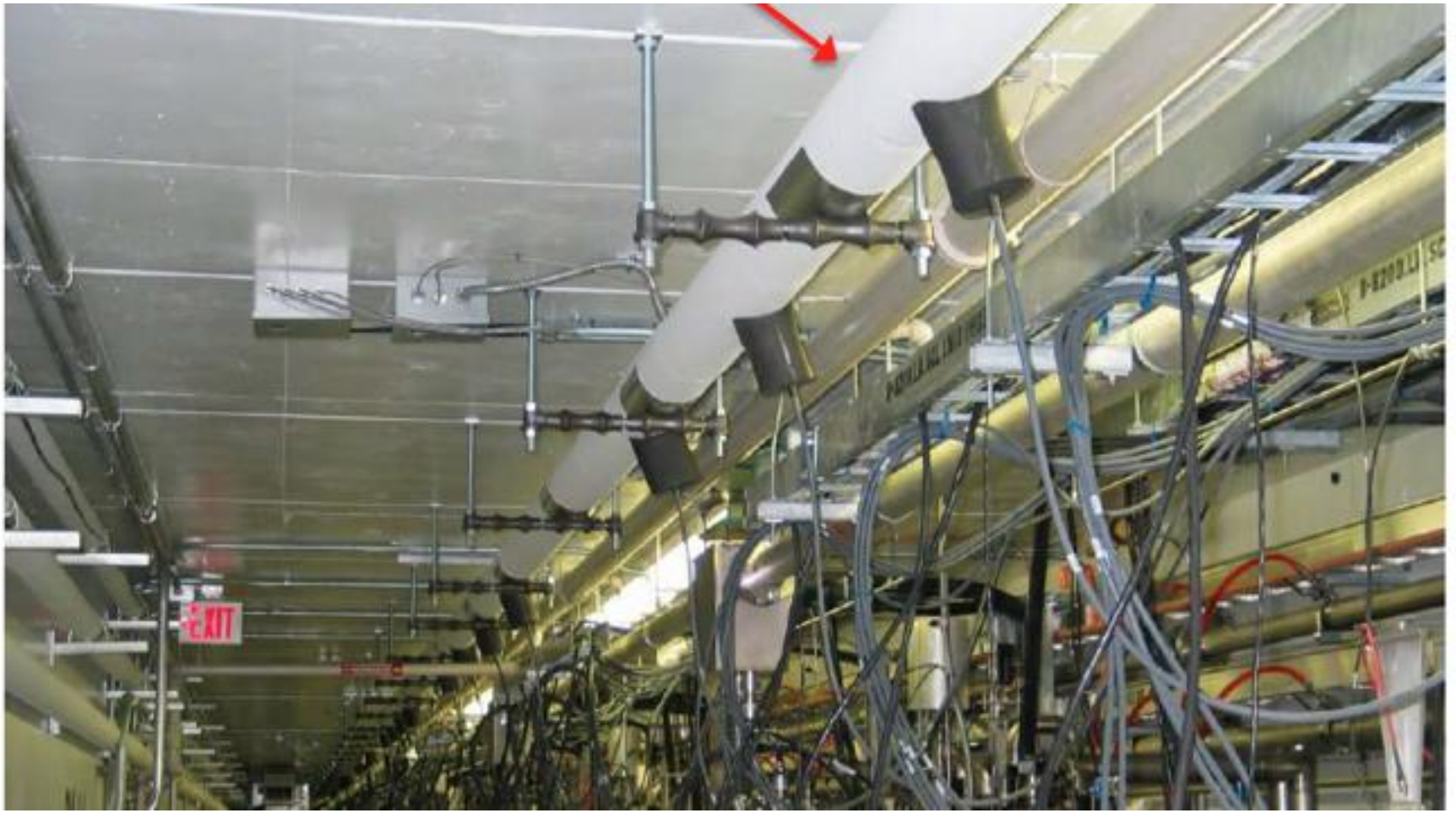
Master Oscillator (MO) and Phase Reference Distribution System (PRDS)

ESS Requirements (by Rihua Zeng):

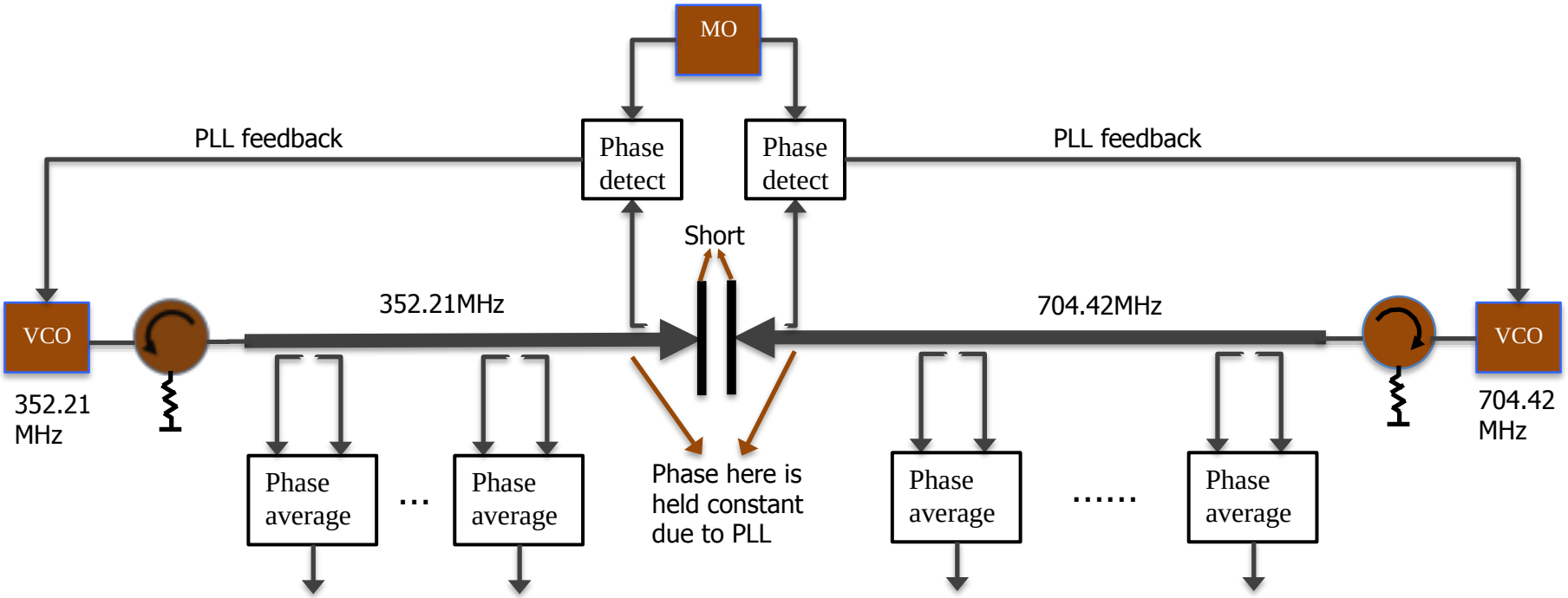
- For LLRF, BPMs, along the whole tunnel
- Stability requirement 0.1° for short term(during pulse), 1° for long term(hours to days)
- Drift ~±6° for 704MHz section (tunnel temperature ±2.5°C, assume cable temperature coefficient 10ppm, only cable, not considering RF components drift). Drift ~12° for 704MHz section + HEBT.
- Drift ~±1.1° for 352MHz section.



Phase Line at SNS



ESS Design for Phase Reference Line



By Rihua Zeng

Some More Details …

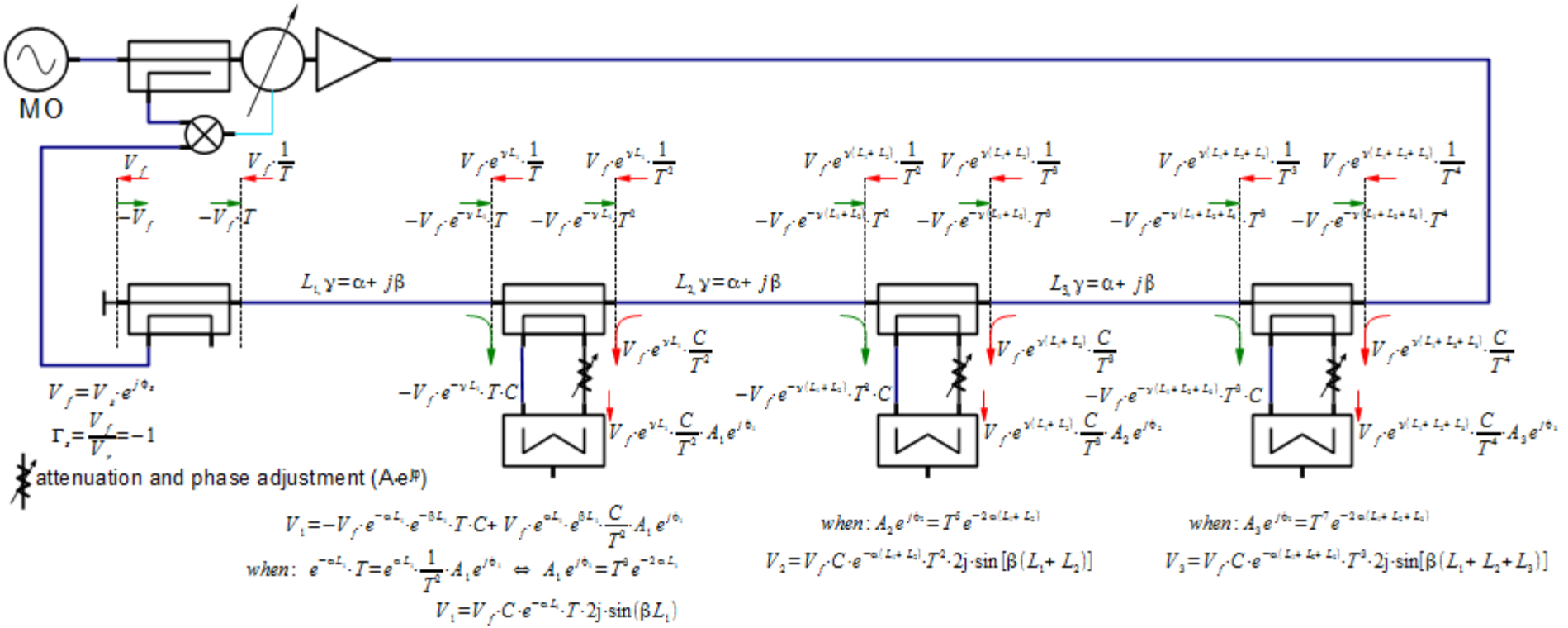
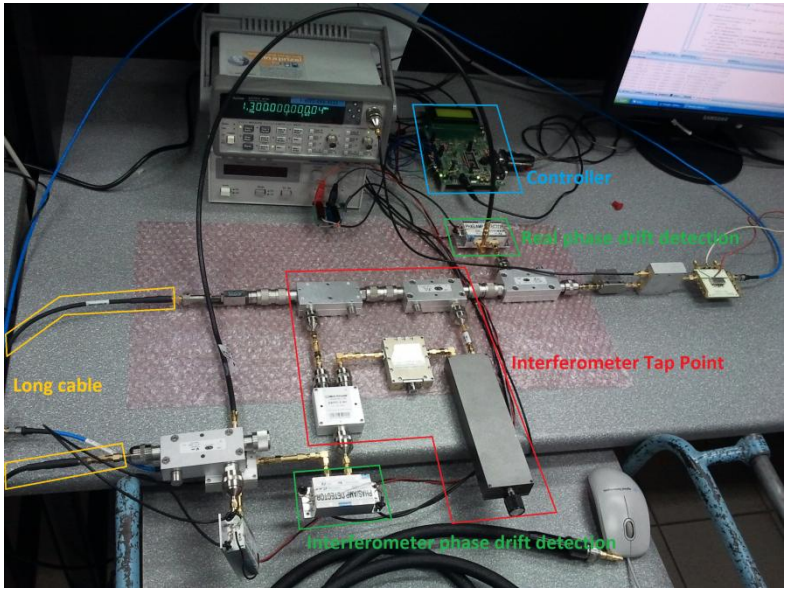
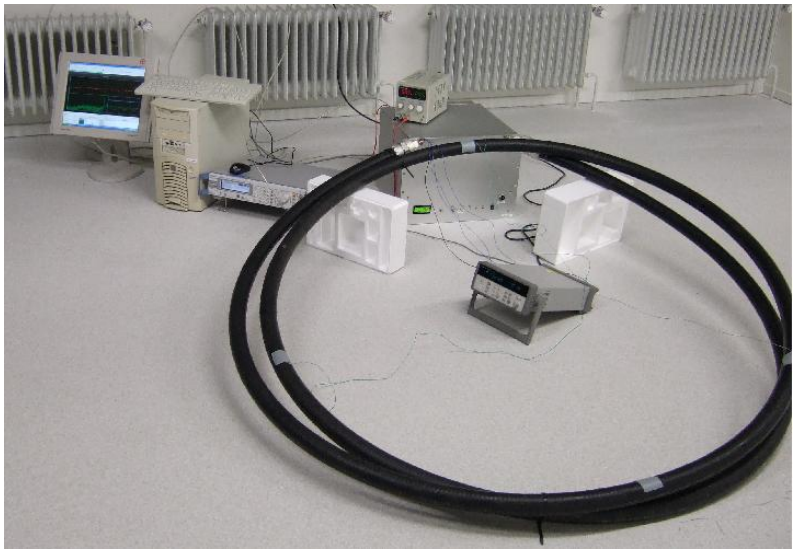
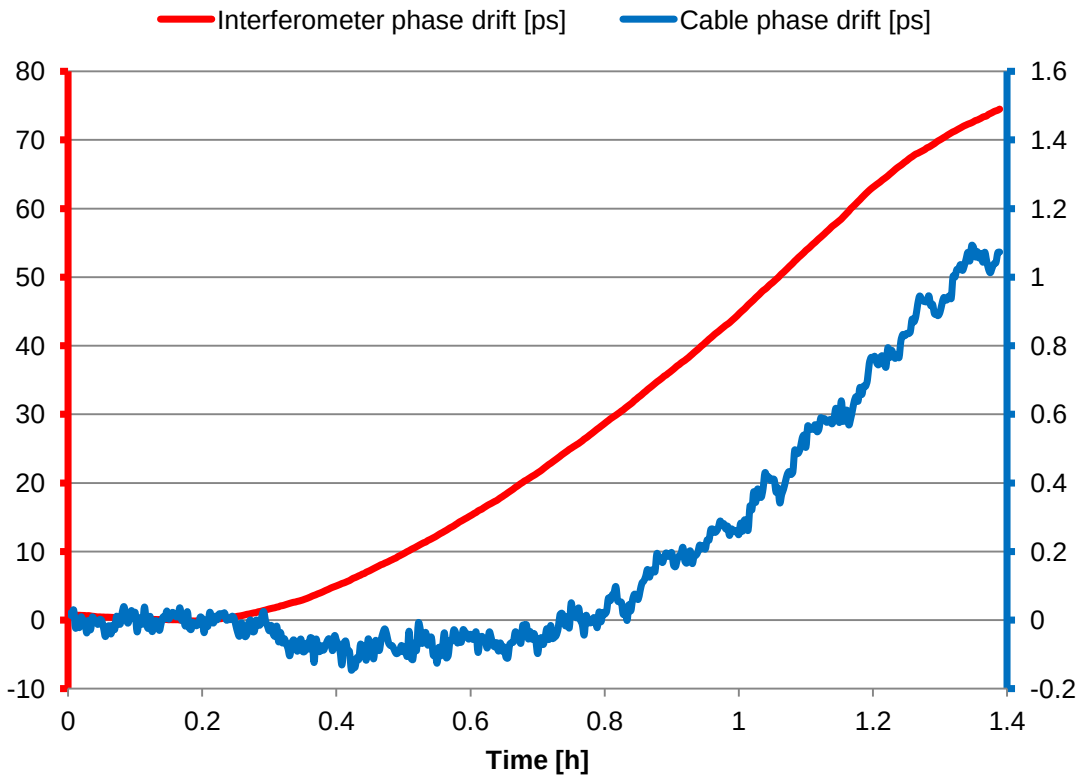


Figure: Courtesy of D. Sikora

WUT Prototype of The Phase Averaging Line







- Tested on the bench, no temperature stabilization
- Cable drifts up to 30 ps are compensated to 80 fs p-p over long term (suppression >300)
- Above 30 ps output phase changes more (suppression 70 to 100)

ACCSYS.8.3: WUT Contribution (1)

A. To support the ESS project by providing technical expertise and integration support for Phase Reference Distribution System.

- Investigate coax cable and other component phase drifts for ESS PRDS
- Develop phase averaging line system for drift compensation
- Find optimum number of tap points for phase stability vs. power loss
- Work out requirements and concept for the Master Oscillator project

B. To support building prototype of phase reference line for ESS and carrying out related elaborate measurements and experiments in WUT laboratories.

- Characterize critical components of the ESS phase reference line
- Test prototypes of distribution links

ACCSYS.8.3: WUT Contribution (2)

C. To be responsible for co-design, the procurement, assembly and testing of the PRDS for the ESS accelerator together with the ESS team

- 155 Cavity systems
- 165 BPM systems
- Master Oscillator

D. To be responsible for the installation and commissioning of phase reference distribution line for all LLRF stations and beam instrumentation stations in the Klystron Gallery and accelerator tunnel of ESS.

- Installation
- Commissioning

Thank you for attention!